

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
15 April 2004 (15.04.2004)

PCT

(10) International Publication Number
WO 2004/031092 A1

(51) International Patent Classification⁷: C04B 7/43,
F27B 7/20, F23J 15/02

JENSEN, Lars [DK/DK]; Hyrdeengen 103, DK-2625
Vallensbaek (DK). HANSEN, Jens, Peter [DK/DK];
Fredriksdalsvej 10D, 1. tv., DK-2830 Virum (DK).

(21) International Application Number:
PCT/IB2003/003171

(74) Agents: KYLIN, Peter et al.; Hynell Patenttjänst AB, Pa-
tron Carls väg 2, S-683 40 Hagfors/Uddeholm (SE).

(22) International Filing Date: 11 July 2003 (11.07.2003)

(81) Designated States (*national*): AE, AG, AL, AM, AT (util-
ity model), AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA,
CH, CN, CO, CR, CU, CZ (utility model), CZ, DE (util-
ity model), DE, DK (utility model), DK, DM, DZ, EC, EE
(utility model), EE, ES, FI (utility model), FI, GB, GD, GE,
GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ,
LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN,
MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO,
RU, SC, SD, SE, SG, SK (utility model), SK, SL, SY, TJ,
TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA,
ZM, ZW.

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PA200201467 2 October 2002 (02.10.2002) DK

(71) Applicant (*for all designated States except US*): F.L.
SMIDTH A/S [DK/DK]; Vigerslev Allé 77, DK-2500
Valby (DK).

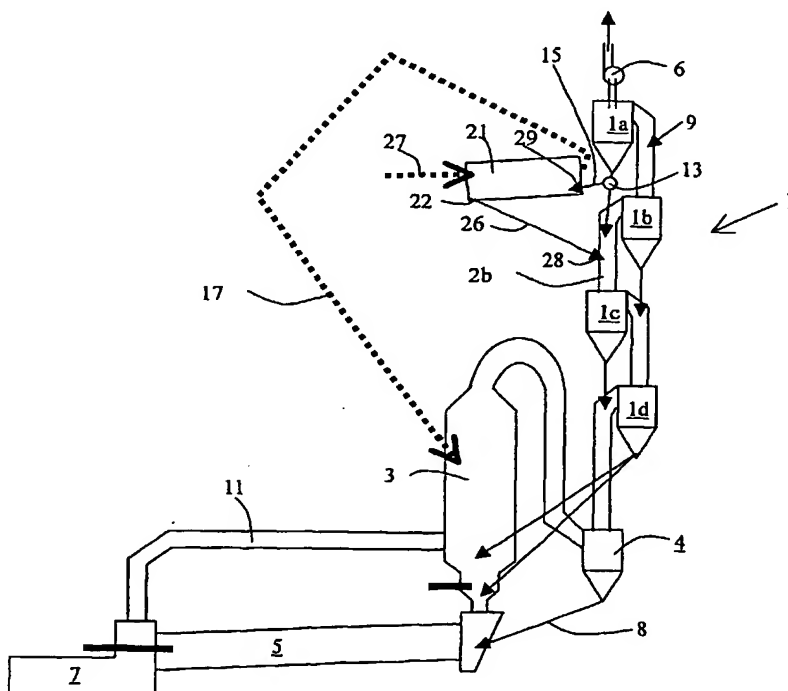
(72) Inventors; and

(84) Designated States (*regional*): ARIPO patent (GH, GM,
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),

(75) Inventors/Applicants (*for US only*): SKAARUP

[Continued on next page]

(54) Title: METHOD AND PLANT FOR MANUFACTURING CEMENT CLINKER



(57) Abstract: Described is a method for manufacturing cement clinker by which method cement raw meal is preheated and burned in a plant comprising a cyclone preheater (1) and a kiln (5). The method is peculiar in that that at least a portion of the raw meal is extracted from the cyclone preheater (1), that this raw meal is introduced into a separate unit (21) in which it is given a retention time under oxidating conditions provided by means of a gas stream for forming SO₂ and for expelling organic carbon, that the formed SO₂ and the expelled organic carbon are subsequently discharged from the separate unit (21) entrained in the gas stream for further treatment in a subsequent process stage, and that the raw meal is reintroduced into the cyclone preheater (1). Hereby is obtained an effective reduction of the VOC, CO as well as the SO₂ emission without necessitating utilization of additional energy for heating. By giving the extracted and partially preheated raw meal a retention time under

oxidating conditions separate from the cyclone preheater it is obtained that sulphide will oxidate into SO₂ and that organic carbon is expelled from the raw meal, so that the thus formed SO₂ and the thus expelled organic carbon can be entrained in a separate, relatively small gas stream and subjected to subsequent treatment in the optimum manner.



Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE,
ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO,
SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM,
GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:

— *with international search report*

METHOD AND PLANT FOR MANUFACTURING CEMENT CLINKER

The present invention relates to a method for manufacturing cement clinker by which method cement raw meal is preheated and burned in a plant comprising a cyclone preheater and a kiln. The invention relates specifically to a method for reducing the emission of SO₂, CO and volatile organic compounds (hereinafter referred to as VOC) from such a plant. The invention also relates to a plant for carrying out the method.

Plants of the aforementioned kind for manufacturing cement clinker are well known from the literature.

The emission of SO₂, CO and VOC from such kiln plants for manufacturing cement clinker emanate primarily from the raw materials which are being used as described in further details in the following text. The heating of the raw meal in the cyclone preheater is done by direct contact with hot exhaust gases according to the counterflow principle, whereby the formed SO₂ and CO and the expelled VOC are immediately captured by the exhaust gas stream, and thus leave the cyclone preheater together with the exhaust gas stream in the form of emission. For different reasons, the three types of emission into the atmosphere are undesirable.

The cement raw materials often contain minerals such as pyrite and marcasite. The sulphide in the pyrite (FeS₂) is converted in the cyclone preheater at temperatures around 525°C, causing SO₂ to be formed. Measurements performed at an operating cement plant have thus shown that virtually all the sulphide contained in the raw meal feed will still be present in the raw meal when it leaves the first cyclone stage at a temperature around 370°C, whereas the sulphide content in the raw meal leaving the second cyclone stage at a temperature around 550°C will be approximately half as high. So, at the cement plant in question nearly one half of the sulphide contained in the raw materials will escape from the preheater in the form of SO₂ as a result of the oxidation process which takes place in the second cyclone stage. A known method for

reducing the SO₂ level involves application of an absorbent in the form of CaO, Ca (OH)₂ or other basic components in the cyclone preheater at a location after, viewed in the direction of flow of the exhaust gases, SO₂ is formed so that SO₂ can be bound in the raw material in the form of sulphite which is transformed into sulphate at a subsequent process stage. One significant disadvantage of this known method is that it will usually be necessary to apply an excess amount of absorbent, thus making it a relatively expensive method.

Also, the cement raw materials will frequently contain organic carbon which is expelled substantially from the raw meal in the form of CO and VOC during the preheating process in the cyclone preheater and being discharged in unburned form together with the exhaust gas stream. This is confirmed by studies which indicate that certain types of VOC are expelled substantially within a relatively narrow temperature span. One type of VOC is thus expelled substantially within a temperature span ranging from 300 to 500°C, whereas another type is expelled substantially within a temperature span ranging from 450 to 650°C. Other additional types of VOC are expelled over greater temperature spans. In a traditional cyclone preheater the aforementioned temperature span will typically occur in the 1st and 2nd cyclone stage, and, respectively, the 2nd and 3rd cyclone stage, dependent on whether the cyclone preheater is a 4-stage or 5-stage unit and also somewhat dependent upon the efficiency of the other elements of the kiln system. Several methods are known for the subsequent treatment of the exhaust gases for removing VOC from the exhaust gases. A known method comprises the steps, that the exhaust gases from the preheater are reheated in a heat exchange unit, that VOC are burned while fuel is simultaneously added, and that the exhaust gases are subsequently cooled in the heat exchange unit. From the viewpoint of energy consumption this is not an optimum solution, and the apparatus for carrying out the method also involves quite substantial investment costs.

30

In addition, from Danish patent application No. PA 2001 00009 is known a method by which raw meal is extracted from the preheater and heated in a separate heating unit for forming SO₂ and for expelling VOC. According to the

known method, the formed SO₂ is subsequently brought into contact with an absorbent, the expelled VOC is burned off, and the raw meal is reintroduced into the cyclone preheater. The disadvantage of this known method is primarily that the energy consumption will be relatively high.

5

It is the objective of the present invention to provide a method as well as a plant for manufacturing cement clinker by which a cheap and effective reduction of SO₂, CO and VOC emission can be achieved without any significant impact on the efficiency level of the cyclone preheater.

10

This is achieved by a method of the kind mentioned in the introduction and being characterized in

- that at least a portion of the raw meal is extracted from the cyclone preheater,
- that this raw meal is introduced into a separate unit in which it is given a retention time under oxidating conditions provided by means of a gas stream for forming SO₂ and for expelling organic carbon,
- that the formed SO₂ and the expelled organic carbon are subsequently discharged from the separate unit entrained in the gas stream for further treatment in a subsequent process stage, and
- that the raw meal is reintroduced into the cyclone preheater.

15

Hereby is obtained an effective reduction of the VOC, CO as well as the SO₂ emission without necessitating utilization of additional energy for heating. By giving the extracted and partially preheated raw meal a retention time under oxidating conditions separate from the cyclone preheater it is obtained that sulphide will oxidate into SO₂ and that organic carbon is expelled from the raw meal, so that the thus formed SO₂ and the thus expelled organic carbon can be entrained in a separate, relatively small gas stream and subjected to subsequent treatment in the optimum manner. As will be described in further details in the following text, studies carried out by the applicant have surprisingly indicated that a significant oxidation of sulphide into SO₂ and a certain expulsion of organic carbon will occur even if the temperature is kept constant and below that at the location in the cyclone preheater where most of the SO₂ release is otherwise

20

25

30

taking place. The studies have also shown that the rate at which these processes are taking place executed depend on the temperature, and that the rate will be increased in step with rising temperatures.

- 5 The plant for carrying out the method according to the invention is characterized in that it comprises means for extracting at least a portion of the raw meal from the cyclone preheater, separate means for giving this raw meal a retention time under oxidating conditions and thereby ensuring oxidation, by means of a gas stream, of sulphide contained in this raw meal for the formation of SO₂ and for
10 the expulsion of organic carbon, means for discharging the formed SO₂ and the expelled organic carbon from the separate unit entrained in the gas stream for further treatment in a subsequent process stage, and means for reintroducing the raw meal into the cyclone preheater.
- 15 Further characteristic features of the plant will be apparent from the detailed description provided in the text below.

It is preferred that all of the raw meal is extracted from the cyclone preheater for oxidation in the separate unit.

- 20 Up to this point in time, conventional wisdom has held that when the raw materials contain sulphurous components, SO₂ will be formed within a relatively small temperature span around 525°C. The studies referred to above and described in further details in the following text have, however, quite surprisingly
25 indicated that a significant oxidation of sulphide into SO₂ will occur even at lower temperatures if only the necessary time is allocated for the process. The studies have thus shown that the formation of SO₂ may occur even at a temperature of 350°C, and according to the invention the raw meal may thus be extracted from the cyclone preheater at a temperature ranging between 350°C and 525°C. In
30 order to limit the necessary time of retention for the extracted raw meal in the separate unit and thus its capacity, it is preferred that the raw meal is extracted from the cyclone preheater at a temperature within the range of 400°C and 500°C. The studies carried out have indicated that at temperatures higher than

525°C, SO₂ will be formed so rapidly that virtually all of the sulphide has been converted into SO₂ before the raw meal is extracted from the preheater.

In principle, the raw meal can be given any retention time in the separate unit which is necessary to attain the desired SO₂ formation at the temperature in question. In actual practice, the temperature of the extracted raw meal will be the main determinant for the duration of the retention time, which is necessary. According to the invention the retention time in the separate unit may be selected at random, but, often, it should advantageously be within the range of 10 to 200 seconds. However, it is preferred that a maximum limit of 100 seconds is applied.

The temperature in the separate unit can be kept substantially constant during the oxidation process, but it may also be varied, for example through regulation of the temperature of the gas stream introduced into the separate unit. If it is desirable to increase the rate of oxidation, the temperature in the separate unit may thus be elevated by introducing a hotter gas stream.

In principle, organic carbon is expelled from the raw meal across the entire temperature span in the cyclone preheater, which in the case of the raw meal ranges from a temperature of less than 100°C at the top of the cyclone preheater to a temperature close to 830°C at the bottom of the cyclone preheater. Therefore, the method according to the invention will only have the capability to expel a portion of the total amount of organic carbon. The temperature at which the raw meal is to be extracted will therefore depend primarily on the temperature at which the maximum reduction of the SO₂ level is achieved. The studies previously referred to in the text have indicated variations in the pattern for expelling different types of organic carbon. Prior to implementation of the method according to the invention at a given cement plant it will, therefore, be advantageous to conduct specific investigations of the raw materials utilized in order to determine exactly their content of different types of organic carbon and further to determine how these are expelled as a function of the temperature. In some cases, where consistent with the SO₂ reduction, it is, therefore, preferred

that the raw meal is extracted from the cyclone preheater at a temperature of less than 450°C.

5 In principle, the oxidation of the extracted raw meal in the separate unit can be done in any suitable manner, however, a smaller oxygen-containing gas stream must be led through the compartment for oxidation of sulphide and organic carbon and for the removal of SO₂ and expelled organic carbon. Studies have indicated that the optimum oxygen percentage for removing SO₂ is approximately 5 per cent.

10

The separate unit may be configured in any suitable manner. The separate unit may comprise any type of receptacle or conveying mechanism for bulk materials, which will be able to provide a sufficient retention time for the raw meal and ensure a sufficient mixing of the raw meal and the oxygen-containing gas stream.

15 For example, the separate unit may be configured as a rotary drum in which the extracted raw meal and the oxygen-containing gas stream are introduced via inlets located at either end of the rotary drum, passed through the rotary drum in counter-current flow and also discharged from opposite ends. Furthermore, it is desirable that the unit or plant comprises means for ensuring that the raw meal

20 after its extraction from the unit will be physically located at, or can be routed to, the level which is necessary for it to be reintroduced at the designated location into the cyclone preheater.

The formed SO₂ which is discharged from the separate unit entrained in the gas

25 stream can be separately treated in, for example, a wet scrubber of known operating principle where SO₂ on reaction with CaCO₃ and H₂O will be transformed into gypsum on the form CaSO₄·2H₂O, and from where the cleaned gas can be released to the environment. The necessary CaCO₃ may be contained in the dust carried along from the separate oxidation unit or it may be

30 supplied in the form of fresh raw meal. Due to the fact that the gas stream through the separate oxidation unit is small relative to the gas stream through the cyclone preheater, the wet scrubber for this purpose may also be relatively small. The water consumption will also be relatively small. The gypsum generated in

the wet scrubber may advantageously be used at the cement mill plant in substitution for some of the ordinary gypsum. In this way a significant amount of sulphur may be bypassed the kiln system of the cement plant, thereby reducing the frequently occurring problems in respect of clogging and obstruction in the
5 kiln system.

The formed SO_2 which is discharged from the separate unit entrained in the gas stream may alternatively be introduced into the cyclone preheater at a location where a sufficient amount of absorbent in the form of CaO and/or other basic
10 components is present, which will typically be at the lower end of the cyclone preheater. In plants where the cyclone preheater comprises a calciner it is preferred that the formed SO_2 is introduced into the said calciner.

The expelled organic carbon can be burned separately or alternatively it may be reintroduced at a location in the cyclone preheater where the temperature is at
15 least 700°C , which will typically be at the lower end of the preheater. In plants where the cyclone preheater comprises a calciner it is preferred that the expelled organic carbon is introduced into the said calciner.

In principle, the extracted and separately oxidated raw meal can be reintroduced into the cyclone preheater at any location. However, it should preferably be introduced immediately after the point of raw meal extraction, viewed in the direction of flow of the raw meal. In other words, it is preferred that the separately oxidated raw meal is introduced into the cyclone preheater at the first cyclone
20 stage after the cyclone stage from which it was extracted.
25

The invention will now be described in further details with reference to the drawing, being diagrammatical, and in which

30 Fig. 1 shows a graphic representation of the formation of SO_2 as a function of the time at different temperatures,

Fig. 2 shows a first example of a plant according to the invention, and

Fig. 3 shows a second example of a plant according to the invention.

Seen in Fig. 1 are graphs a – d for the formation of SO_2 as a function of the time at the temperatures 350, 375, 400 and 500°C. The illustrated graphs are a direct result of a series of tests which have been conducted by the applicant. The tests have been conducted in a fixed bed reactor according to the method described in the following. A material sample was preheated to a desired temperature in an inert hot gas consisting of pure N_2 . The hot exit gas from the inert heating process was mixed with O_2 in order to oxidate any evaporated sulphur into SO_2 . Following inert heating during a period of 240 seconds, O_2 was added to the N_2 stream before the stationary bed. This procedure was followed to make certain that there would not be any significant oxidation of the material sample during the relatively slow heating process and that the supply of O_2 would take place swiftly relative to the chemical reaction so that the rate of reaction could be studied at a given temperature and independently of the heating process. The SO_2 content as a function of the time was measured throughout the test procedure. In Fig. 1 that part of the graphs where t is less than 0 shows the SO_2 formation which occurs in connection with the heating of the material in the inert gas whereas the graphs for t greater than 0 show the SO_2 formation when the temperature is kept constant and when O_2 is supplied. It clearly appears from the figure that the formation of SO_2 is a very slow process during the inert heating process up to the point where t is equal to 0 and that subsequently, when O_2 is supplied when t is equal to 0 the formation rate is much faster. In particular the graphs b, c and d show that the conversion of sulphide into SO_2 takes place predominantly within the initial 100-second period whereafter the graphs are levelled out, presumably trending towards maximum conversion which, in respect of the material being used during the test, will be approximately 30, 50 and 70 per cent, respectively, at the respective temperatures 375, 400 and 500°C. So, out of these three temperatures the immediate conclusion would be that the optimum method would involve extraction of the raw material at a temperature around 500°C since the highest degree of conversion is achieved at this temperature. However, it should be noted that in connection with the heating to a

level of 500°C in the inert gas, a quite significant amount of SO₂ will be formed which in actual practice will not be transferred to the separate unit. So, the optimum temperature for extracting the material in question seems to be within the range of 400° to 500°C.

5

In Figs. 2 and 3 are seen two examples of plants according to the invention. Both of the plants shown comprise a cyclone preheater 1, a rotary kiln 5 and a clinker cooler 7. The cyclone preheater 1 comprises four cyclone stages a-d, a calciner 3 and a separation cyclone 4. The cyclone preheater 1 may comprise fewer as
10 well as more than the four cyclones indicated. Raw meal from a not shown raw mill plant is introduced into the cyclone preheater via one or several inlets 9 and preheated in a counter-current arrangement with exhaust gases whereafter it is separated from the cyclone preheater in the cyclone d and directed to the calciner 3 in which it is calcined. From the bottom outlet of the separation
15 cyclone 4, the calcined raw meal is then directed via a duct 8 to the rotary kiln 5 in which it is burned into cement clinker which is subsequently cooled in the clinker cooler 7. The exhaust gases from the rotary kiln 5 and the calciner 3 are drawn through the cyclone 4 and then up through the cyclone preheater by means of a fan 6. Tertiary air from the clinker cooler 7 is introduced via a duct 11
20 into the calciner 3.

According to the invention at least some of the raw meal is extracted from the cyclone preheater 1 with a view to subjecting it to oxidation in a separate unit 21 in which the raw meal is introduced via a duct 15. In order for the separate
25 oxidation of the raw meal to have any significant effect upon the formation of SO₂ and the expulsion of organic carbon, the raw meal must of course be extracted from the preheater before the majority of the sulphide content has been transformed into SO₂ and /or before the content of organic carbon has been expelled from the material. In instances where it is only desirable to carry out
30 separate oxidation of some of the raw meal, it can be extracted from the raw meal flow from the bottom outlet of the selected cyclone stage via, for example, a splitter gate 13.

The separate unit 21 shown in Fig. 2 and 3 comprises a rotary drum 21. A gas stream is introduced via an inlet 27 at one end of the rotary drum and the extracted raw meal is introduced via an inlet 29 at the opposite end, causing the mixing of the raw meal and the gas stream to be effected in a counterflow arrangement. The raw meal is extracted from the other end of the rotary drum 21 via an outlet 22 and directed via a duct 26 and transport means, if any, back to the cyclone preheater 1 into which it is reintroduced via an inlet 28 which is located immediately after the point at which it was extracted, viewed in the direction of flow of the raw meal.

In the embodiment shown in Fig. 2 the gas stream containing SO_2 and the expelled organic carbon is led from an outlet 29 in the rotary drum 21 via a duct 17 to the calciner 3 in which all organic carbon is burned off and SO_2 is absorbed under optimum temperature conditions by reaction primarily with CaO .

In the embodiment shown in Fig. 3 the gas stream containing SO_2 and the expelled organic carbon is led from the outlet 29 in the rotary drum 21 via the duct 17 to a wet scrubber 31 in which it is cleaned according to known principles where SO_2 by reaction with CaCO_3 and H_2O will be transformed into gypsum on the basis of the form $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, and from where the cleaned gas can be released to the environment, possibly via a unit 33 for burning CO and VOC.

In connection with the implementation of the invention at an existing cement plant it will often be necessary to set the temperature in the preheater at a level which will allow the raw meal to be extracted at the desired temperatures. This can be done in a number of ways. If it is desirable to lower the temperature at the specific location in the preheater where the raw meal is to be extracted for the separate oxidation, it will be possible to introduce, for example, atmospheric air at an appropriate location. However if it is desirable to raise the temperature at the specific point of extraction, the raw meal feed may, for example, be split up and a smaller quantity of raw meal may be bypassed. Also, the temperature can be adjusted by controlling the quantity of raw meal being extracted for the

separate oxidation. Other means of regulation consist in a modification or regulation of the separation efficiency of the preheater cyclones.

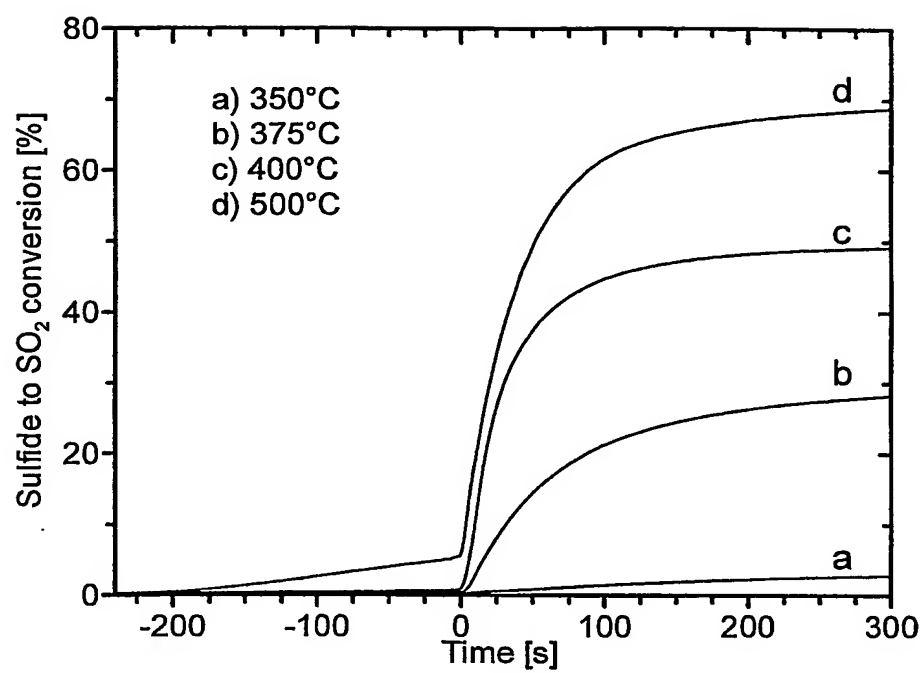
5 In actual practice it may be necessary to regulate the capacity of the separate unit 21 and in the case of a rotary drum this may be done by changing its rotational speed. An increase in the rotational speed of the rotary drum will lead to a reduction in the retention time of the raw meal in the drum, entailing a corresponding reduction in the amount of SO₂ being formed and the organic carbon being expelled. In order to compensate for any such reduction, heat may
10 be supplied to the separate unit 21, possibly by introducing a partial flow stream of the hot air from the clinker cooler 7 into the unit 21 via the inlet 27.

Patent claims

1. Method for manufacturing cement clinker by which method cement raw meal is preheated and burned in a plant comprising a cyclone preheater (1) and a kiln (5), **characterized in**
- that at least a portion of the raw meal is extracted from the cyclone preheater (1),
 - that this raw meal is introduced into a separate unit (21) in which it is given a retention time under oxidating conditions provided by means of a gas stream for forming SO₂ and for expelling organic carbon,
 - that the formed SO₂ and the expelled organic carbon are subsequently discharged from the separate unit (21) entrained in the gas stream for further treatment in a subsequent process stage, and
 - that the raw meal is reintroduced into the cyclone preheater (1).
2. Method according to claim 1, **characterized in** that all of the raw meal is extracted from the cyclone preheater (1) for oxidation in the separate unit (21).
3. Method according to claim 1 or 2, **characterized in** that the raw meal is extracted from the cyclone preheater (1) at a temperature between 350°C and 525°C.
4. Method according to claim 1 or 2, **characterized in** that the raw meal is extracted from the cyclone preheater (1) at a temperature between 400°C and 500°C.
5. Method according to claim 1 or 2, **characterized in** that the temperature in the separate unit (21) is kept substantially constant during the oxidation process.
6. Method according to claim 1 or 2, **characterized in** that the raw is given a retention time in the separate unit (21) within the range of 10 to 200 seconds, preferably within the range of 10 to 100 seconds.

7. Method according to claim 1 or 2, **characterized in** that the that the formed SO_2 and the expelled organic carbon , and which is discharged from the separate unit (21), is introduced into the calciner (3) of the cyclone preheater.
- 5 8. Method according to claim 1 or 2, **characterized in** that the extracted and separately oxidated raw meal is introduced into the cyclone preheater (1) immediately after the point where it was extracted, viewed in the direction of flow of the raw meal.
- 10 9. Plant for carrying out the method according to claim 1 comprising a cyclone preheater (1) and a kiln (5), **characterized in** that it comprises means (13, 15) for extracting at least a portion of the raw meal from the cyclone preheater (1), separate means (21) for giving this raw meal a retention time under oxidating conditions and thereby ensuring oxidation by means of a gas stream of sulphide
15 contained in this raw meal for the formation of SO_2 and for the expulsion of organic carbon, means (17) for discharging the formed SO_2 and the expelled organic carbon from the separate unit (21) entrained in the gas stream for further treatment in a subsequent process stage, and means (26) for reintroducing the raw meal into the cyclone preheater.
- 20 10. Plant according to claim 9, **characterized in** that it comprises a wet scrubber (31) for treatment of the formed SO_2 , which is discharged from the separate unit (21) entrained in the gas stream.

1/3

**Fig. 1**

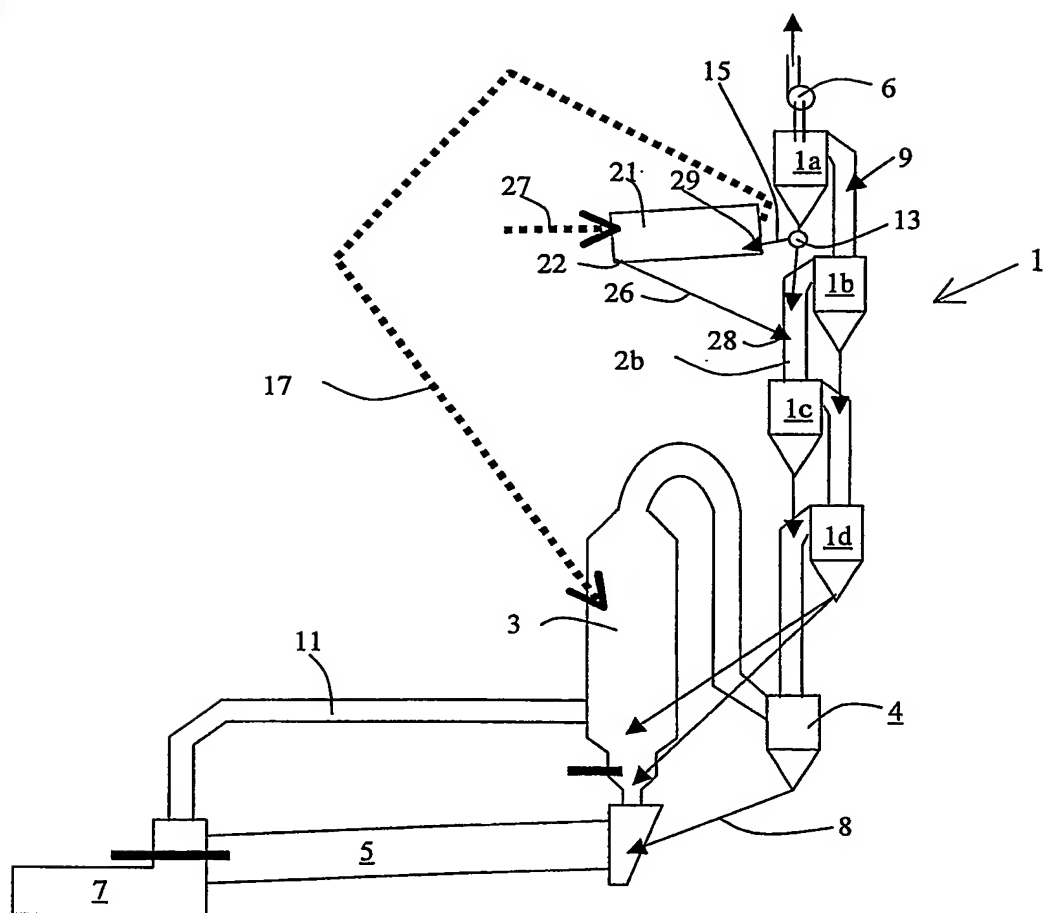


Fig. 2

3/3

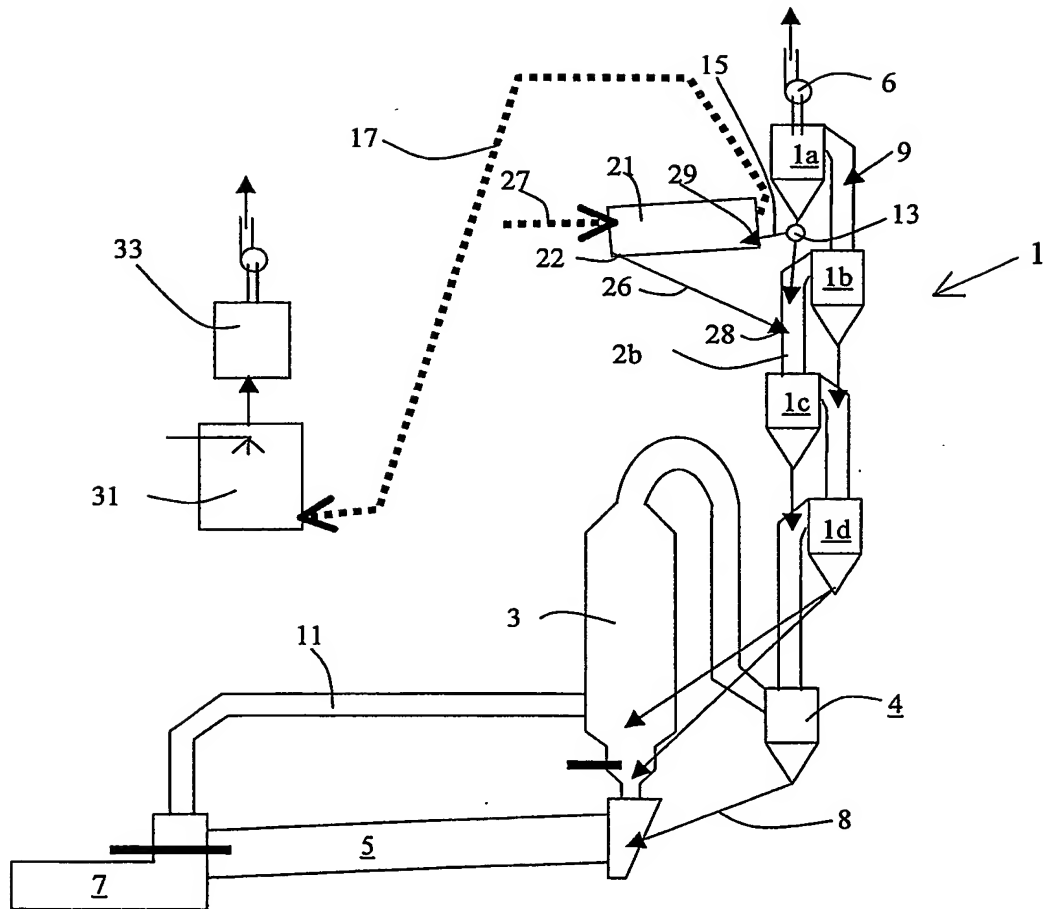


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 03/03171

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: C04B 7/43, F27B 7/20, F23J 15/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: C04B, F27B, F27D, F23J, F23G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI DATA, EPO-INTERNAL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6325620 B1 (OTTO HEINEMANN), 4 December 2001 (04.12.01), abstract --	1-10
A	US 4576644 A (WOLF GOLDMANN), 18 March 1986 (18.03.86), abstract --	1-10
P,A	US 2003/0056935 A1 (HANS-WILHELM MEYER ET AL), 27 March 2003 (27.03.03), abstract --	1-10
A	WO 9310884 A1 (F.L. SMIDTH & CO. A/S), 10 June 1993 (10.06.93), abstract --	1-10

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

27 October 2003

Date of mailing of the international search report

12 8 -10- 2003

Name and mailing address of the ISA/
Swedish Patent Office
Box 5055, S-102 42 STOCKHOLM
Facsimile No. +46 8 666 02 86

Authorized officer

Ulrika Nilsson/MP
Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 03/03171

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5927967 A (KLAUS BAUER ET AL), 27 July 1999 (27.07.99), abstract --	1-10
A	EP 0228111 A1 (METALLGESELLSCHAFT AG), 8 July 1987 (08.07.87), abstract -- -----	1-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

06/09/03

International application No.

PCT/IB 03/03171

Patent document cited in search report			Publication date	Patent family member(s)	Publication date
US	6325620	B1	04/12/01	DE 19936375 A	08/02/01
US	4576644	A	18/03/86	BR 8306427 A	31/07/84
				DE 3244241 A	30/05/84
				DE 3361934 D	00/00/00
				EP 0110079 A,B	13/06/84
				ES 527408 A	01/08/84
				ES 8406397 A	01/11/84
				JP 59107951 A	22/06/84
				ZA 8307688 A	27/06/84
US 2003/0056935	A1	27/03/03	NONE		
WO	9310884	A1	10/06/93	DK 191291 A	26/05/93
				MX 9206754 A	01/05/93
US	5927967	A	27/07/99	DE 19649663 C	02/04/98
				EP 0845443 A	03/06/98
				TR 9701461 A	00/00/00
EP	0228111	A1	08/07/87	SE 0228111 T3	
				AT 46088 T	15/09/89
				CA 1284802 A,C	11/06/91
				CZ 280413 B	17/01/96
				CZ 8609150 A	15/11/95
				DD 252767 A	30/12/87
				DE 3544764 A	19/06/87
				DE 3665410 D	00/00/00
				DK 165736 B,C	11/01/93
				DK 606386 A	19/06/87
				ES 2011251 T	01/01/90
				HU 49057 A	28/08/89
				HU 200706 B	28/08/90
				JP 2034465 C	19/03/96
				JP 7053224 B	07/06/95
				JP 62144736 A	27/06/87
				SK 278406 B	09/04/97
				SK 915086 A	09/04/97